THE STRUCTURAL GEOLOGY AND PETROLOGY OF AN AREA NEAR YASS, NEW SOUTH WALES.

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(Plates vi–vii; nine Text-figures.)

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A study of the geology of the neighbourhood of Yass was undertaken to determine the nature of the igneous rocks, and their relationship to the sediments. In addition, it was hoped to find a zone fossil to enable correlation to be made with rocks of other districts.

The area studied comprises the whole or portion of the parishes of Hume, Yass, Warroo, Boambolo, Bowning, Derringullen and Nanima; Shire of Goodradigbee; Counties of King, Murray and Harden.

The town of Yass is situated on the Yass River, a tributary of the Murrumbidgee. It is 1,620 feet above sea-level, on the Southern Highlands of New South Wales, 198 miles by rail, south-west of Sydney. A short branch line connects the town with the Sydney-Melbourne railway line. It is 33 miles by road, north-west of Canberra.

About 50 square miles has been studied in detail, stretching from the town for 7 miles south, and from a north and south line through the town, for 3 miles east and 3 miles west. The remainder of the 120 miles shown in the sketch map (Text-fig. 9) has been examined cursorily.

Previous Literature.

Jenkins (1878*a*) described the igneous and sedimentary rocks of Yass and the surrounding country. He separated the fossiliferous beds into lower (Yass beds) and upper (Hume beds) horizons, subdividing these further. He classed Yass and Hume beds within the Silurian formation, separating them from the Murrumbidgee limestone. He noted the absence of graptolites. Later (1878*b*) he described trilobites collected by himself. David visited Yass (1882) shortly after joining the Geological Survey. He mapped the area and noted the geological structures. Mitchell, in two early papers (1886, 1888), dealt principally with the geology of Bowning, describing a synclinal structure there, and the fossil content of the beds. He refers to the presence of graptolites "from mica sandstones in the Lower Trilobite bed on the east side (i.e., of the syncline), and in shaly sandstones on the west side in the Great Shale bed". In later papers (1919–1923) he describes trilobites and brachiopods from the district.

Geology owes a debt to Mr. A. J. Shearsby for his study (1911) of the geology and palaeontology of the district. His descriptions and map cover a wide area and systematize the previous observations. As well as his published work, his knowledge and guidance are always at the service of inquirers. Harper (1909), dealing principally with the area afterwards submerged by the Burrenjuck dam, referred to the Yass porphyry, which is considered of Post-Devonian age.

Mann (1921) regarded the igneous rocks at Yass as intrusive on account of the presence of contact-breccias. Etheridge (1894–1917) described fossils from many parts of the area, and several other short references are to be found (Cotton, 1923; Wilkinson, 1876).

Physiography.

A parallelism is to be noted in the physiographical features of the area shown on the map (Pl. vii), three ridges running approximately NNW.–SSE., with two intervening valleys, being the most pronounced features. On the eastern ridge is situated the Douro Trigonometrical Station, and on the second are the Laidlaw and Racecourse Stations. These names have been used in writing of the localities. The third is referred to as the Euralie–Warroo ridge, Euralie homestead and Warroo Trigonometrical Station being situated on it. The eastern valley, viz., that between Douro and Laidlaw ridges, is occupied by the town of Yass, the main street of which, Cooma Street, occupies the lowest ground and was formerly alongside a water-course flowing into the Yass River. The westerly valley is drained by two tributaries of the Yass River, Booroo Ponds Creek and Reedy Creek, which are fed by drainage from Laidlaw and Euralie–Warroo ridges. The Yass River has cut a passage across the ridges, but not before it was greatly deflected by them. Pronounced swingings to the north mark the river's course, when it first meets each ridge, and only after some distance of northward flow has a westerly course been carved, along which the river has the nearly vertical sides of a young stream. Across the softer beds of the valley between Laidlaw and Euralie ridges, the Yass River pursues the low-banked straight course of a mature stream. Differential erosion is responsible for the ridges. It will be shown that they mark the outcrop of coarse-grained igneous rocks, while the valleys have been carved in softer sedimentary rocks. Coarse gravel deposits in places, above the present river, mark levels of its former course. Alluvium has been deposited by the tributaries to Reedy Creek and Booroo Ponds Creek at points where their flow has been slackened by arrival on the relatively flat ground where sandy shales outcrop, after descent from higher land, as in Portions 16, the western part of 18, and southern 15, Parish of Hume. The course of Warroo Creek is checked by hard igneous rocks in Portion 62, Parish of Boambolo, and alluvium has been deposited, which here, as elsewhere, masks the geology. The lower course of Reedy Creek is marked by rather high, open banks rising to about 50 feet above the valley.

General Geology.

(*Note.*—The numbers, as S.53, refer to specimens and thin sections in the author's collection.)

a. *Igneous Rocks and Tuffaceous Sediments.*

The junctions between the different rocks of the area lie along more or less parallel lines, on account of their conformability. They are folded into a geosyncline with a pitch to the north-west. Igneous rocks are either interbedded or intrusive along bedding-planes. Transgressive intrusion plays but a minor part. With one or two possible exceptions, all rocks belong to the Upper Silurian system. The oldest members of the synclinal structure are exposed beside the river immediately north-east of Laidlaw Trigonometrical Station, where a fine-grained, quartz-rich, highly micaceous, black tuff, 20 feet wide, dips WSW. at 20 degrees. This bed underlies a finer, more iron-stained type, which has a steeper dip in the same direction. A thin section of this rock can hardly be distinguished from a felspathic mica sandstone, although it is probably of tuffaceous origin, since all its fragments are angular. Poorly preserved specimens of *Orthoceras* occur within it. A similar micaceous sandstone, rich in *Leperditia shearsbii* Chapm. (1909), on the same line of strike outcrops in Portion 100, Parish of Yass, and in a section on the opposite bank of the Yass river in Portion 14, Parish of Yass, described by Shearsby (1911) and regarded by him as the type section of the Yass beds, or lower member of the Upper Silurian rocks of the district. The section is about half a mile downstream from the railway bridge. The beds here are richly fossiliferous with *Ceratioceras, Cycloceras, Leperditia, Pterinea, Spirifer, Barrandella*, etc. Closely comparable lithologically and stratigraphically with these is a bedded rock (S.27) outcropping in Douro Creek, Portion 22, Parish of Hume. Tuffs and thin limestone bands are intercalated in some of these sections, and calcium carbonate has percolated into some of the tuffs, for example, into that exposed in a rock cutting on the Hume Highway, 1½ miles east of Yass. Well marked bands of limestone, striking at 7 degrees, outcrop in Portions 107 and 108, Parish of Yass. This is a porous rock of a fragmental nature, with broken corals, quartz grains and fragments of tuff. Almost the whole of the low-lying Rifle Range in Portion 8, Parish of Hume, is covered by limestone, in places strongly contorted, apparently by the neighbouring porphyry intrusion.

Overlying the series of fine tuffaceous sediments with intercalated limestone, near Laidlaw Trigonometrical Station (Text-figure 5), occurs a coarse-grained grey igneous rock, whose fragmental nature is not apparent until it is examined in thin section. In a hand specimen the rock resembles a porphyry, but it proves to be a coarse crystal tuff (Pirsson, 1915), with large angular fragments of quartz and felspar, some of which fractured in place before consolidation of the rock (*see* Petrological Descriptions). The fractured edges of adjoining fragments in some cases undoubtedly match, and would interlock if they could be brought into contact (Text-figure 6). The same feature has been detected in the "porphyroides" of the French and Belgian Ardennes (Poussin and Renard, 1876, 1897), and is also noted in the quartz-porphyry tuffs of the Yass District; it is discussed below. Coarse crystal tuff covers a large part of the area, being found in Portions 100, 103, 106, Parish of Yass, and in Portions 18 and 20, Parish of Hume, as well as in the Parishes of Boambolo and Warroo. The rock outcropping along a narrow ridge through Portions 45, 49, 53 and 57, Town of Yass, SSE. of Laidlaw Trigonometrical Station, though perhaps better described as a volcanic grit, is regarded as of similar origin. By the conversion of its matrix into secondary silica, the volcanic grit passes into quartzite, for example in the rifle range in the east of Portion 8, Parish of Hume, near the border of the quartz-porphyry. The relationship of coarse crystal tuff, volcanic grit and quartzite to quartz-porphyry tuff will be discussed later.

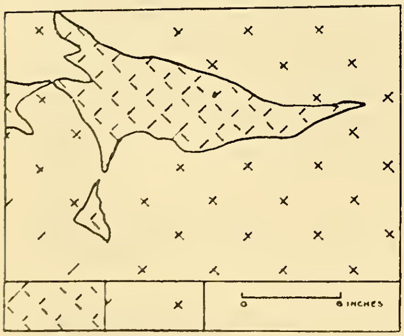
The fossils collected near Yass by Shearsby (1911) from coarse-grained igneous rocks, hand-specimens of which resemble porphyries, probably occurred in rocks of this type, and the presence of fossils further supports the theory of their pyroclastic origin.

The crystal tuffs, etc., junction with porphyry along a nearly straight north-west and south-east line, running parallel to the strike of the sediments, and passing through a point 150 yards north-east of Laidlaw Trigonometrical Station. The porphyry is a grey and white coarse-grained rock, easily to be confused with the crystal tuff, until examined in thin section, when it proves to be a normal quartz-porphyry with a devitrified ground-mass (*see* Petrological Descriptions). Careful collection and examination in thin section of specimens every twenty-five yards north-east of Laidlaw Trigonometrical Station has failed to disclose any rocks with texture transitional between that of crystal tuff and porphyry. A sharp junction separates the types (Text-figure 5). Hexagonal jointing has developed in the porphyry, an exposure in a rock pavement showing traces of well-marked joints bearing at 75 degrees, 195 degrees and 315 degrees. On the edge of a steep slope to the river, 50 yards north-east of Laidlaw Trigonometrical Station, porphyry columns 7 feet high and 2 feet in diameter are exposed. In a quarry within the golf links, in Portion 8, Parish of Hume, columnar development is also found.

Xenoliths of tuff, fine- and medium-grained, several inches in diameter, are not uncommon in the porphyry, and are regarded as being due to dislodgment by the porphyry during its intrusion.

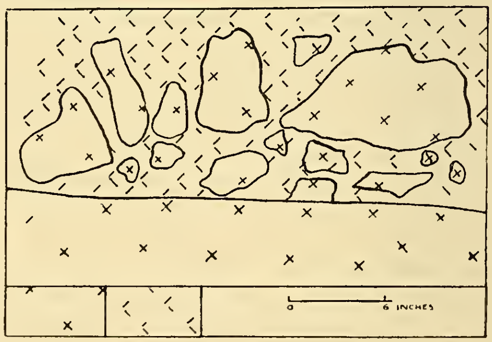
Ten yards to the west of Racecourse Trigonometrical Station, the porphyry has suffered devitrification (Harker, 1909; Shand, 1927; Tyrrell, 1926) so intense as to have become almost a quartzite. (S.477; *see* Petrological Descriptions.) This is the furthest extension to the south-east of the Laidlaw ridge porphyry. To the north-west the outcrop trends across the Yass River, which has cut a passage through porphyry from Portion 108, Parish of Yass, to Portion 97, Parish of Yass. From Portion 97 a line running roughly south-east marks the junction of porphyry with tuffs. The intrusion of the porphyry is pictured as having taken place in the manner of a sill, since its junctions on both sides with neighbouring bedded strata run nearly parallel with their strike, viz., north-west and south-east.

Evidence of the period at which the intrusion of the porphyry took place has not been obtained. Its mineral contents ally it with the interbedded tuffs of the area, and it has undergone devitrification to about the same extent as they. These circumstances suggest that the intrusion took place shortly after the laying down of the tuffs. The river has exposed, in Portion 97, Parish of Yass, the junction between the porphyry and a fine-grained rock (Text-figures 1, 2).



1

Tuff? Porphyry.



2

Porphyry. Tuff?

Text-figs. 1, 2.—Relations between quartz-porphyry and fine-grained rock in Portion 97, Parish of Yass.

The conclusion that the fine-grained rock is intrusive into the porphyry seems inescapable. It occurs in masses up to 18 by 6 inches in cross-section, and is also seen in thin strings, about half an inch in width and 30 to 40 feet long, ramifying through the porphyry in all directions. These veinlets are generally dark-blue-grey in colour, though some are red. Thin quartz-veins are also present. For a width of 100 feet, the exposed face of the porphyry contains these inclusions. The porphyry is finely jointed here, joint-planes being only half an inch apart in places, and the rock is rotten. The fine-grained material is a dense, blue homogeneous material, suggesting a chert. Extremely fine and even-grained, in thin section it is nearly isotropic, though small rectangular fragments of secondary quartz can be discerned and minute mica flakes are arranged as though along bedding-planes. In places, mica flakes are concentrated in strings at right angles to the bedding-planes. With a high-power objective, a devitrified mass of spherulites, probably all of secondary quartz, can be detected. This material may have been intruded into the solid porphyry, which caused its very rapid cooling and solidification as a glass, and it has subsequently become devitrified. It is also possible that movements along the junction of porphyry and the fine-grained material have formed a kind of fault-breccia, causing the squeezing of the fine-grained rock into the porphyry. A sharp junction separates normal porphyry from that associated with the fine-grained material (Text-figures 1, 2). Whatever the origin of the breccia-like rock, it seems that the thin string-like veins must be intrusive. The microscopic character of this fine-grained material is similar to that of rocks from the Parish of Boambolo described below (S.101 and S.577), which have been classified, though somewhat doubtfully, as fine tuffs. In this connection, however, it is noteworthy that Cox and Wells (1920), writing of the Lower Palaeozoic rocks of North Wales, state "the true rhyolites of Mynydd-y-Gader bear an extraordinary resemblance to tuffs". Benson (1915) has described an intrusion of a tuffaceous breccia at Tamworth, N.S.W., of a grain-size, however, coarser than the intrusive material described here.

To the south-west, the porphyry of the Laidlaw ridge is succeeded by fine- to medium-grained tuffs, about 1,000 feet in thickness. The best section is exposed by the Yass River, upstream from Hatton's Corner, in Portions 94 and 97, Parish of Yass, where the dip is 15 to 30 degrees WSW. In the direction of dip, tuffs outcrop for an average width of 800 yards and vary in texture, but the mineral constituents remain uniformly quartz, altered felspar, chloritized biotite and iron oxide set in a devitrified groundmass. Texturally, three main divisions may be distinguished: medium-grained (type 1), bedded or banded (type 2), and fine-grained (type 3). Tuffs from all over the area have been grouped according to these divisions. Type 2 includes tuffs whose bedding traces are sometimes only detected with the aid of the microscope. These, and indeed most rocks of Type 2, are probably variants of types 1 or 3, local pressure having caused re-orientation of the minerals with their long axes parallel. In other parts of the area, rhythmic banding appears to be due to periodic variations in the nature of the deposit, for example, in a road-cutting in Portion 7, Parish of Warroo. Fine-grained tuff (type 3) adjoins the Laidlaw ridge porphyry to the south-west and is overlain by medium-grained tuff (type 1), which in turn underlies bedded tuff (type 2) (Text-figure 3). A fractured face of type 3 is exposed in the municipal quarry in the south-east of Portion 8, Parish of Hume, 150 yards south of Racecourse Trigonometrical Station, where doubtful traces of fossils may be found. About 50 yards to the west of the quarry the tuff is intensely devitrified, showing geodes of agate and chalcedony. Normal devitrification has probably been reinforced by invasions of siliceous solutions along the junction of tuff and porphyry (Harker, 1909; Shand, 1927; Tyrrell, 1926). In places this type of tuff is spotted, the spots being centres of advanced devitrification. The spots are sometimes visible to the naked eye, sometimes only in thin section (S.420).

The medium-grained tuff (type 1) overlying type 3, outcrops for 600 yards across the dip. A tributary to Black Bog Creek exposes a 20-foot section of this tuff dipping west at 10 degrees. It is grey when fresh, as in Portion 8, Parish of Hume, near the boundary of Portion 111, Parish of Yass, or in the bed of the Yass River, where it contains narrow veins of red siliceous material. Its outcrop is interrupted by a coarse agglomerate, which forms two persistent bands standing six to nine inches above the level of the tuffs and running parallel to their bedding. The bands are of low boulders and are about 40 feet apart. Each band is about 10 yards wide and strikes SSE. The bands are continuous across much of Portion 8, Parish of Hume, and may be followed across Portion 94, Parish of Yass, nearly to the Yass River, and in the opposite direction nearly to the municipal quarry. At the south-west corner of the rifle range, in Portion 8, Parish of Hume, the band of agglomerate widens out considerably into a circular area about 25 yards in diameter. Mr. Shearsby has traced agglomerate into Portion 55, Parish of Yass, north of the Yass River (personal communication).

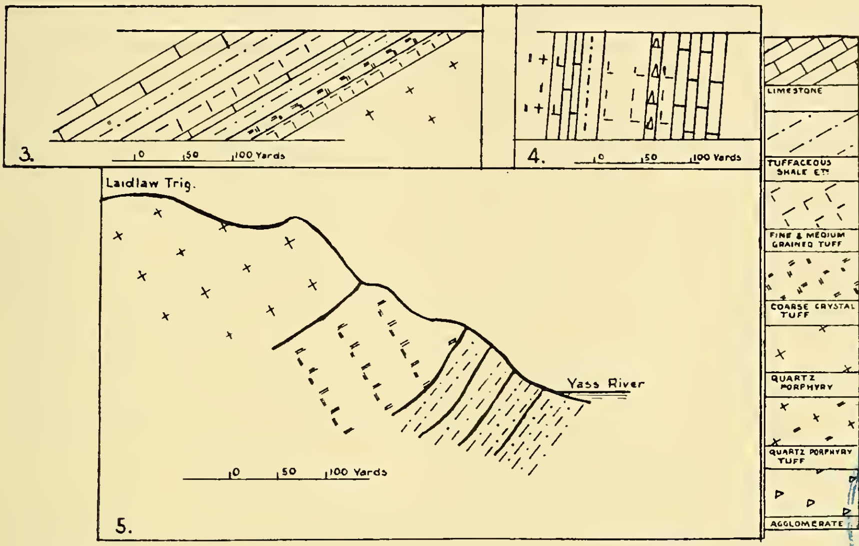
The fragments making up the agglomerate are of fine (type 3) and medium tuff (type 1) up to half an inch across. The rock is an interbedded pyroclastic rock, and for some miles follows the bedding of the tuffs and is not transgressive. It has been deposited after a period of intense explosive activity.

Another interruption in the deposition of medium-grained tuff (type 1) in Portion 8, Parish of Hume, is shown by a restricted outcrop of coarse crystal tuff similar to that found north-east of Laidlaw Trigonometrical Station, but here containing limestone fragments, which occurs 100 yards west of the south-west corner post of the rifle range. It is probably connected with a much weathered volcanic conglomerate outcropping in the bank of the Yass River, in Portion 97, Parish of Yass, 50 yards from the boundary of the porphyry, where it is clearly interbedded with tuffs (Text-figure 3). Another small outcrop of coarse crystal tuff occurs within the rifle range.

The sequence of tuffs in Portion 8, Parish of Hume, is brought to a close by the bedded tuff (type 2), which can be seen dipping at 10 degrees SW., conformably below limestone in the bed of Yass River, near the junction of Portion 8, Parish of Hume, with Portion 94, Parish of Yass, and also in the bed of Booroo Ponds Creek, about half a mile south-east of its junction with the Yass River.

Agglomerate does not outcrop across the valley along which the Wee Jasper Road now runs; indeed, the absence of such a competent bed may explain the development of a valley between the ridges capped by agglomerate, for agglomerate can be traced again south-east of the junction of the Wee Jasper and Gums Roads, Portion 14, Parish of Hume, where it strikes SSE., parallel to the strike of the tuffs. It accompanies a suite of tuffs similar to those in Portion 8, Parish of Hume. No section is exposed, but a traverse ENE. from the corner of the Wee Jasper and Gums Roads shows that the agglomerate is interbedded with the medium-grained tuff (type 1), beneath which fine tuff of type 3 outcrops. The fine tuff overlies coarse crystal tuff, whose direction of strike is the same as that of the coarse crystal tuff to the north-east of Laidlaw Trigonometrical Station, and they are lithologically similar. Included among the tuffs on this traverse are some which have undergone such intense devitrification that they are now almost pure quartz. It is considered that silica solutions percolating between bedding planes, or along concealed strike fault planes, have accelerated the devitrification process in these cases.

No porphyry is exposed in this traverse. Sir Edgeworth David noted (1882) that the Laidlaw porphyry does not outcrop south of Racecourse Trigonometrical Station.



Text-figs. 3, 4.—Sequence of rocks exposed by the Yass River in Portion 94, Parish of Yass (Fig. 3), and Portion 64, Parish of Warroo (Fig. 4).

Text-fig. 5.—Ideal section from Laidlaw Trigonometrical Station to the Yass River, Portions 112 and 113, Parish of Yass.

The country east of Gums Road is well grassed, and outcrops are poor. Along the junction of Portions 17 and 18, Parish of Hume, east of Gums Road, fine tuff (type 3) is succeeded by coarse crystal tuff, dipping WSW. at 20 degrees. Agglomerate is not exposed here. To the south, Portion 148, Parish of Boambolo, and adjoining portions are covered by a green, dense tuff, with a smooth surface and waxy lustre, dipping NNW. at 15 degrees. The rock is extremely fine-grained and intensely devitrified, perhaps best described as a chert or hälleflinta (Harker, 1919). It is, indeed, doubtful if this rock was originally a tuff, but since, in the hand-specimen, it resembles the undoubted tuffs of Portion 202, Parish of Warroo, and of the municipal quarry, in spite of the greater devitrification visible in a thin section, it is described here as a fine tuff belonging to type 3 (S.101, S.577). Agglomerate lithologically identical with those previously described, and with a dip varying between W. and NNE., separates the fine tuff from a bedded tuff of type 2, which, in turn, overlies coarse crystal-lithic tuff (S.155), containing remarkable elliptical xenoliths of pink crystal tuff of a type which can be matched in outcrops elsewhere in the area, notably near the 7-mile post on the Wee Jasper Road. The matrix of the crystal-lithic tuff is the normal crystal tuff familiar north-east of Laidlaw Trigonometrical Station. In Portion 108, Parish of Boambolo, remarkable tors, 10 feet high, are formed of this rock, and it caps a bold hill in Portion 90, Parish of Boambolo.

The Euralie-Warroo ridge forms the western limb of the geosyncline, of which the rocks of the Laidlaw Ridge are the eastern members, and the structure of which will be described later. Approaching the ridge from the east the rock sequence of the eastern limb in Portion 8, Parish of Hume, is passed over in the reverse order (see Geological Sketch Section, Plate vii). A conformable series made up of a blue-grey slate (regarded as the indurated equivalent of the Barrandella shales, described below), a resistant limestone, lithologically exactly similar to the Bowspring limestone (described below), and a medium-grained tuff (type 1 or 2), all dipping at 100 degrees ENE., is passed over in travelling from east to west in Portion 64, Parish of Warroo (Text-figure 4). This dip is regarded as due to local overfolding or faulting, because slightly to the north in Portion 148, Parish of Warroo, the limestone is dipping at 75 degrees ENE., and to the south, in Portion 60, Parish of Warroo, the medium-grained tuff and agglomerate dip to the north-east at 40 degrees, and at 60 degrees ENE., in Portion 15, Parish of Boambolo. Agglomerate interrupts the tuff sequence at Euralie, as elsewhere in the area. It is lithologically similar on the Euralie ridge to other outcrops, standing up in a resistant low wall which runs parallel to the strike of the tuffs. The repeated association of this rock in conformity with the same tuff sequence is a strong argument for a similar origin for all, that is a pyroclastic origin for the agglomerate. Cuttings on the Goodhope Road, immediately west of the Euralie turn-off, and on the bank of Yass River, east of the junction with Euralie Creek, expose a tuff of type 3 underlying agglomerate, followed by a medium-grained tuff (type 1) with interbedded thin bands of limestone and sandstone (Text-figure 4).

At the Yass River, in Portion 64, Parish of Warroo, near the junction of Euralie Creek, the sequence of fine- and medium-grained tuffs is succeeded by a coarse-grained crystalline rock, which seems best described as a quartz-porphyry-tuff. It differs materially from the porphyry of the Laidlaw ridge, but resembles the crystalline rock forming a fringe on the east of the area, and is discussed with it later.

To the south of Euralie, the sequence of fine- and medium-grained tuffs is succeeded by coarse crystal tuff, similar to the rock so named elsewhere in the area, and quite distinct from the quartz-porphyry-tuff of Euralie. Coarse crystal tuff forms the Warroo Trigonometrical Station ridge and extends in a direction generally south-south-east from Portion 213, Parish of Warroo. Quartzite outcrops in Portions 59, 64, 103 and 147, Parish of Warroo, are considered to have developed from coarse crystal tuff by devitrification intensified by the attack of siliceous solutions (*see* Petrological Descriptions).

The Douro ridge, on the east of the area, is formed of a coarse-grained quartz-porphyry which, like that of the Laidlaw ridge, meets sediments (tuffaceous sandstones) along its western border in a line parallel to the strike of the sediments, and so is regarded as having been intruded between bedding planes. Xenoliths of tuff, the coarse crystal and the bedded varieties, are not uncommon in the porphyry. Along their junction, both porphyry and tuffaceous sediments have been intensely devitrified and acted upon by siliceous solutions. Porphyry outcropping in Portion 24, Town of Yass, and bedded tuff in Portion 47, Town of Yass, have been converted to chert. In Portion 32, Parish of Hume, the porphyry and banded tuff are almost completely silicified. The process is less complete in Portion 21, Parish of Hume, 300 yards north of the Hume Highway, where the otherwise normal Douro porphyry, grey and coarse-grained, contains large patches (4 inches in diameter) of chalcedonic silica enveloping primary quartz and altered plagioclase crystals. A strip about a quarter of a mile wide running generally north-west and south-east along the margin of the porphyry has been affected. The invasion of siliceous solutions seems to have been the last phase of the intrusion of the Douro porphyry, affecting the western margin of the porphyry itself as well as the adjoining tuffaceous sediments. The parallelism of this line of intrusion to the strike of the sediments is considered to be due to the intrusion, as a sill, of the Douro porphyry between the bedding planes of the tuffs and tuffaceous sediments. The passage of siliceous solutions along bedding-planes, or possibly along concealed strike-fault planes, accounts also for the replacement by silica of some of the corals in the Bowspring limestone, near Hatton's Corner, and for the occurrence of quartz crystals, sometimes double-ended, half an inch in length in the tuffaceous grits in Portion 45, Town of Yass.

Fresh specimens of the Douro porphyry can be obtained in a quarry 150 feet above the left bank of the Yass River about half a mile up-stream from the Hume Highway bridge in the town, at a point called Hibernia Crescent (Shearsby, 1911). It is a coarse-grained, greyish-green rock, rich in quartz, and contains xenoliths of quartz-grit up to fifteen inches across. This quartz-grit is related to coarse crystal tuffs outcropping nearby, notably the volcanic grit of Portions 45, 49, 53 and 57, Town of Yass. The xenoliths were probably displaced by the porphyry during its intrusion between bedding-planes of the tuffs. Porphyry outcropping in Portion 21, Parish of Hume, half a mile north of the Hume Highway, also shows large included fragments of fine bedded tuff (type 2).

Forming a fringe on the east of the area, the rock outcropping in Portions 23, 24, 26, 27 and 30, Parish of Hume, and from Portions 6 to 16, Parish of Nanima, suggests, like the Euralie "porphyry", a normal quartz-porphyry in the hand-specimen, but an examination in thin section reveals differences. Though phenocrysts of idiomorphic quartz, plagioclase, chlorite and apatite bring the rock into line with the porphyries, small irregularly-shaped quartz and felspar fragments are packed so closely between the phenocrysts that the interstitial ground-mass is reduced to a minimum. Some of the quartz phenocrysts are shattered, the fragments remaining close together, with mere threads of interstitial ground-mass between them (Text-figure 7).

The name "quartz-porphyry-tuff" has been adopted to describe this type. They are vividly recalled, when reading descriptions of the rocks of the Belgian and French Ardennes by Ch. de la Vallée Poussin and A. Renard (1876, 1897). These rocks, previously known as "porphyroides", the authors say, are composed of crystals of felspar, which are cracked, broken and rounded off on the angles, and of crystals of quartz with corroded borders and seldom idiomorphic. They have so little cement as to have almost a granitic texture except that crystals have such poorly defined contours. They say, further, "it is noticeable that adjacent fragments have belonged to the same crystal", and that fragmentation is so general that the rocks must be clastic. The authors put forward the alternative hypotheses that the minerals composing these rocks were either of volcanic origin, and were projected directly into sea-water, fracturing on impact; or that they are the disintegrated products of a rock attacked by atmospheric agents, and are still *in situ*. T. G. Bonney (1885) considers these rocks of the French Ardennes to have been lavas, and ascribes the present fragmental condition of their mineral components to devitrification. Though both are composed mainly of quartz, plagioclase and chlorite, the crystal tuffs of the Yass district differ from quartz-porphyry-tuff in being composed of mineral grains, all of which have been corroded or worn by attrition, since none show crystal outlines. They are packed even more closely than in the quartz-porphyry-tuff, so that the proportion of crystals to matrix is higher. Felspar is greatly altered and unidentifiable, while comparatively fresh in the quartz-porphyry-tuff, and secondary minerals, such as calcite, are common in crystal tuff. The constituents of the crystal tuffs may have come from the same source as those forming the quartz-porphyry-tuffs, but they have undergone considerable weathering before consolidation, while those of the quartz-porphyry-tuff consolidated without so much intermediate weathering.

The outcrops of both tuffs show parallel strikes, and crystal tuff in Portion 18, Parish of Hume, is conformable in dip and strike with Upper Silurian limestone. It has been shown already that lithologically similar crystal tuff in Portion 112, Parish of Yass (i.e., NE. of Laidlaw Trigonometrical Station), is interbedded with fossiliferous Upper Silurian sediments. It is concluded, therefore, that the quartz-porphyry-tuff, like the crystal tuff, is Upper Silurian in age.

A belt of igneous rock which covers most of Portions 25 and 28, Parish of Hume, and Portions 7, 8, 71 and 72, Parish of Boambolo, is composed of a tuffaceous type, which differs from the quartz-porphyry-tuff in having a marked flow structure, and a higher proportion of ground-mass to phenocrysts. It is described as a rhyolite-tuff. The direction of the elongation of the outcrop is almost a direct south-south-eastern continuation of the Laidlaw porphyry, whose outcrop was interrupted at Racecourse Trigonometrical Station, but no evidence has been found to connect them. It seems likely that the rhyolite-tuff is also interbedded with the Upper Silurian rocks, but it is also possible that it is connected with the Devonian rocks to the south of this area.

b. Sedimentary Rocks.

The sedimentary series forms an elliptical enclave bounded by the igneous rocks already described. The sedimentary rocks and the tuffs are conformable where junctions are observable at Hatton's Corner and near Euralie.

The sedimentary series, ushered in by the Bowspring Limestone at Hatton's Corner, has been described by Shearsby (1911), who gave the name to the limestone. This limestone, about 300 feet thick, conformably overlies bedded tuff and outcrops across about 250 yards horizontally, its dip increasing from 10 to 30 degrees SW. It is crystalline and fragmental, the fragments often being in the form of elliptical boulders, about 3 inches along their greatest diameter, which are almost in contact. At Hatton's Corner, a cliff of the limestone, 90 feet high, is exposed, and is made up of alternate rows, each about 3 inches wide, of grey-blue ridges formed of such boulders, separated by less resistant material. A freshly-broken specimen has a brecciated appearance, while fossil fragments are exposed on a weathered surface.

Four hundred yards of shales, named "Barrandella" by Etheridge (1904), succeed the Bowspring limestone, dipping 10 degrees WSW., the bed being about 250 feet thick. They are compact, blue-grey, indurated, micaceous shales. They break with a semi-concave fracture, and show no sign of a slaty cleavage, nor trace of close bedding planes. The abundant *Barrandella* is preserved in almost transparent calcite with a pearly lustre.

Lithologically, the Barrandella shales vary only slightly from the sandy shales which overlie them. These are somewhat coarser in grain and contain more iron. Occasionally a greater concentration of iron has caused the formation of a pronounced ridge, on the weathered surface of which a rich fauna has been preserved, especially fragments of *Dalmanites*. Both types of shale break up along closely-set, somewhat curved joint-planes after exposure to the atmosphere for any length of time, when it is difficult to obtain a specimen larger than one cubic inch, except from beds with a high iron content. The sandy shales outcrop for about 2 miles across the dip, that is, to the south-west, and for a considerable distance to the south-east and north-west. They are occasionally interrupted by thin bands of limestone, which may represent conformable inliers of the underlying limestone. Indeed, a synclinal fold can be observed in the Bowspring limestone on the north bank of the Yass River, about Portion 148, Parish of Yass, near Hatton's Corner. What evidence of dip is available supports this view, notably in the case of the limestone outcropping at the 5-mile post on the Wee Jasper Road (see Map, Plate vii), which is probably the locality referred to by Etheridge (1894, 1907) as Old Limekilns Ridge. Concealed strike faulting, however, may have caused the repetition. The Yass River has exposed a series of anticlines and synclines in the sandy shales (see Pl. vii). The angle of folding becomes steeper westward, until, near Reedy Creek, a cliff face shows dips up to 80 degrees, as well as fracture (Pl. vi, fig. 11).

Highly dipping folds continue west of Reedy Creek, the strata exposed in the banks of the Yass River being nearly vertical, while the rock has become indurated to slate. Just before reaching the junction of Euralie Creek and the Yass River, a limestone band is crossed, as has already been described. This limestone is regarded as being the Bowspring limestone thrown up in this place by synclinal folding. It dips ENE. at 100 degrees or WSW. at 80 degrees, tuff outcropping to the WSW. An overfold must be postulated if this limestone is the Bowspring bed, and with almost vertical folding, an overfold may be expected, though faulting may intervene. The limestone outcrop is twice crossed by the Yass River at Euralie, striking across Portion 144, Parish of Yass, and being met again in Portion 103, Parish of Warroo, on the left-hand bank, while immediately to the east is shale (Barrandella, also thrown up by the syncline) striking NW. and with an almost vertical dip. The fossils recorded by Shearsby (1911) from limestone at Euralie, and by Etheridge (1907) from limestone and shale in Portions 53, 126 and 161, Parish of Yass, and from Portion 103, Parish of Warroo, which are all close by, give forms nearly identical with those from the Bowspring limestone and the Barrandella shales at Hatton's Corner, lending palaeontological support to the hypothesis of the synclinal fold.

Strong folding has been traced along Booroo Ponds Creek in Portion 7. Parish of Hume, and in cuttings along the Goodhope Road, such as about 5·1 miles from Yass, where folding and fracturing of the strata may be seen, and in the bed of Reedy Creek at the Goodhope Road. Along the Wee Jasper Road, cuttings expose comparatively low dips.

In Portion 62, Parish of Boambolo, near its junction with Portion 15, shafts have been sunk to exploit galena-bearing quartzites, dipping SW. at 60°. They are succeeded to the south-west by shales, with *Favosites*, *Mucophyllum crateroides*, *Atrypa reticularis*, *A. pulchra*, *Stropheodonta conica*, *Barrandella*, etc., regarded as the equivalent of the Barrandella shales, which give place in turn to a limestone, lithologically similar to the Bowspring type. The occurrence of a fault has been tentatively suggested to account for the sudden change of dip found about 400 yards to the south-west, where fine tuff (type 3) and agglomerate dip at about 60 degrees to the north-east in Portion 15, Parish of Boambolo. The presence of galena lends support to the postulation of a fault plane, which would provide an avenue for the mineral vapours.

Mitchell (1886) recorded a synclinal structure, with axis beneath Bowning Hill, illustrating it by a geological section. His west-dipping strata are exposed in Sharpening Stone Creek in Portions 7 and 8, Parish of Yass, while strata dipping 40 degrees east may be seen in Portion 94, Town of Bowning. Along the railway line between Bowning and Binalong, about Portion 146, Parish of Bowning, soft shales rich in brachiopods also dip at 40 degrees east. Beds exposed in the cutting near Bowning railway station are dipping 85 degrees east, and those exposed in Bowning Creek near the railway line have a practically vertical dip also. This synclinal structure is regarded as a continuation to the north-west of the Yass geosyncline (Text-fig. 9).

Stratigraphical Horizon.

The discovery of graptolites not far from Yass (Sherrard, 1934) has made possible the correlation of this locality with other Silurian areas. *Monograptus*? was recorded by Shearsby (1911). Mitchell (1886) also makes a brief reference to the collection of "graptolites from mica sandstones in the Lower Trilobite bed on the east side" (i.e., of the syncline) "and in shaly sandstones on the west side".

In the course of the present work, graptolites have been found in Portion 34, Parish of Derringullen, to the west of the road to Boorowa, 7 miles north-west of Yass. The fossils occur in a fine-grained felspathic sandstone, probably of tuffaceous origin. It forms a prominent ridge, 200 feet above the road, and is lithologically similar to the sandy shales found to the west of Hatton's Corner in ridges of which *Dalmanites* and other forms have been preserved. Indeed, the graptolite-bearing strata are believed to be extensions to the north-west of these sandy shales, since both overlie the same series, viz., the Barrandella shales. The Barrandella shales form the bed of Limestone Creek, a quarter of a mile to the east of the graptolite-bearing strata, and are richly fossiliferous, as Shearsby (1911) has recorded. Going eastward from Limestone Creek, Bowspring limestone, tuffs and porphyry are passed over, as at Hatton's Corner (Text-fig. 9).

In Portion 34, Parish of Derringullen, *Monograptus* is very common, and is associated with brachiopods, remains of both being found on the same slab of sandy shale. The specific determinations of Monograptidae have been made under the direction of Mr. R. A. Keble, Palaeontologist to the National Museum, Melbourne, who generously gave the writer the benefit of his extensive experience.

The following forms have been identified: *Monograptus vomerinus* Nich., *M. flemingii* Salt., *M. dubius* Suess, *M. vulgaris* Wood, *M.* cf. *nilssoni* Barr., *M. colonus* Barr., var. *compactus* Wood.

These forms indicate Zones 26 to 33 of Elles and Wood (1913), from which it is inferred that this bed and its continuation at Hatton's Corner are equivalents of the beds at the base of the Lower Ludlow division and at the top of the Wenlock division of the Upper Silurian of Britain. The equivalent bed in Victoria is the Yarravian, as defined by Thomas and Keble (1933).

The writer hopes to have the opportunity of publishing full descriptions of these forms later.

Slabs with brachiopods and graptolites on the same surface have also been submitted to Mr. Keble, and the following identifications made:

Atrypa fimbriata (?)	is associated with	*Monograptus vomerinus*
A. reticularis L. sp.	,, ,, ,,	*M.* cf. *nilssoni*
Chonetes melbournensis Chapm.	,, ,, ,,	*M. vomerinus*
C. bipartita	,, ,, ,,	*M.* cf. *nilssoni*

Nucleospira australis McCoy	is associated with	*M. vulgaris*
N. australis	,, ,, ,,	*M. flemingii*
N. australis	,, ,, ,,	*M. vomerinus*
Meristella sp.	,, ,, ,,	*M. vulgaris*
Meristella sp.	,, ,, ,,	*M. dubius*
Meristella sp.	,, ,, ,,	*M. vomerinus*
Barrandella linguifera Sby. var. *Wilkinsoni* Eth. fil.	,, ,, ,,	*M. dubius*

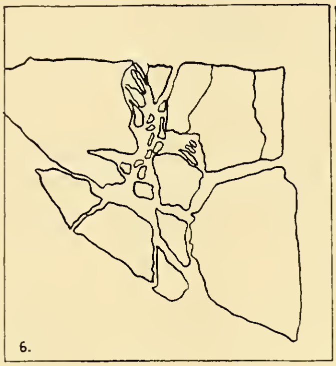
The association of graptolites with brachiopods of the class Articulata in arenaceous deposits is unusual. Ruedeman (1934) notes the association of small, primitive Inarticulata with graptolites in black, carbonaceous shales, while such an association in such shales has been described by the writer (1929).

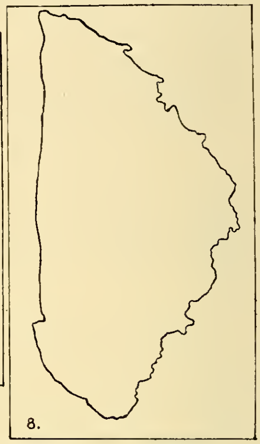
Petrological Descriptions.

Quartz-porphyry.—The Laidlaw ridge quartz-porphyry (S.389; Pl. vi, fig. 1) is a coarse-grained grey and white rock composed of white felspathic crystals, some of which are idiomorphic, transparent quartz grains, and some black idiomorphic ferro-magnesian crystals. It is not uncommon for the black crystals to stand out from a broken surface so as to be detachable whole. Xenoliths of fine-grained material are frequent. In thin section, the phenocrysts of quartz are found to be much cracked and so much corroded that crystal boundaries are seldom perfect. The large hypidiomorphic plagioclase crystals are about $Ab_{60}An_{40}$, while some are zoned, and are slightly clouded by alteration. There are also some smaller plagioclases, and idiomorphic green biotite flakes somewhat chloritized. Accessory minerals include apatite, some galena and probably rutile. The fine-grained ground-mass making up about two-thirds of the rock consists of a devitrified mass of intergrown felspar and quartz showing spherulitic structure, with minute chlorite flakes.

This rock is referred to as "normal quartz-porphyry" throughout the paper. The porphyry in the neighbourhood of the Douro Trigonometrical Station differs somewhat. Its colour is greenish and it contains few white felspars. In thin section, devitrification of the ground-mass is seen to be more intense than in the Laidlaw rock, while the proportion of ground-mass to phenocrysts is nearly 1:1. Large apatite crystals show remarkable inclusions of rutile along cleavage planes intersecting at 120 degrees (S.10).

Quartz-porphyry-tuff.—These rocks are coarse in grain and greyish-green in colour. Mineral phenocrysts and fine-grained xenoliths stand out well. Thin sections show closer packing of the phenocrysts than in the porphyry. Small, angular or rounded grains of quartz and felspar are packed between large, hypidiomorphic, corroded and cracked quartz crystals, prismatic felspars of composition about $Ab_{60}An_{40}$, and flakes of chloritized biotite. Apatite is common, generally containing rutile inclusions along cleavage planes. Sphene is rare. The strongly devitrified ground-mass, showing spherulitic structure, occupies not more than 10–20% of the area. Traces of flow-structure are not uncommon. In places, the character of the broken edges of adjoining pieces of quartz shows unmistakably that they originally belonged to one quartz crystal, which must have fractured on the impact when it came to rest after violent extrusion (Text-figure 7). Typical of this tuff is the rock outcropping in Portion 23, Parish of Hume, at the intersection of the Hume Highway and the road from Yass to Canberra (S.169; Pl. vi, fig. 2). A further example occurs on the Euralie ridge, where specimens have been collected from Portion 62 (S.143) and 115 (S.604), Parish of Warroo. The rock of Portion 6, Parish of Nanima, is also typical (S.173).





Text-fig. 6.—Fractured quartz crystal in coarse crystal tuff (S.220), Portion 100, Parish of Yass. Drawn with camera lucida. × 25.

Text-fig. 7.—Fractured quartz crystal in quartz-porphyry-tuff (S.173), Portion 6, Parish of Nanima. Drawn with camera lucida. × 25.

Text-fig. 8.—Quartz crystal with corroded and jagged outline from rhyolite-tuff (S.572), Portion 71, Parish of Boambolo. Drawn with camera lucida. × 25.

Rhyolite-tuff.—The rock of the narrow igneous tongue stretching south from Portion 25, Parish of Hume, has been described as a rhyolite-tuff, from the fluidal texture of its ground-mass. In a hand-specimen it differs only slightly from a quartz-porphyry or from a quartz-porphyry-tuff. Pink and cream felspar, glassy quartz and black ferro-magnesian minerals are the phenocrysts set in a greyish-green ground-mass. In addition chalcedonic patches about 1 inch in diameter are not infrequent. In thin section, the quartz fragments are seen to be of the most remarkable outline, corrosion having carved out re-entrant angles in their edges, leaving them serrated and jagged (Text-fig. 8; Pl. vi, fig. 3). The felspar is intensely altered to sericite and kaolin, and cannot be more exactly identified. Chlorite occurs in flakes, parallel to, and across the cleavage, calcite sometimes penetrating between cleavage laminae. Galena and apatite are accessories. Small angular pieces of quartz and felspar are packed between the larger fragments of these minerals. Flow-structure is pronounced in the ground-mass. Some lithic fragments are present. The ground-mass when fluid has taken a course around some of the phenocrysts, corroding them. The ground-mass is highly devitrified, now consisting of an intergrowth of secondary quartz and felspar spherulites. The chalcedonic patches observed in a hand-specimen are due to local greater devitrification, which has formed larger spherulites. S.572 from Portion 71, Parish of Boambolo, shows these characters (Pl. vi, fig. 3).

Devitrified Porphyries.—In some cases, intense devitrification has practically converted porphyry into chalcedony, chert or quartzite (Harker, 1909; Shand, 1927; Tyrrell, 1926). An intermediate stage is seen in Portion 21, Parish of Hume, 400 yards north of the Hume Highway, where more than half the ground-mass of the porphyry is chalcedonic (S.449). In thin section, the rock is like a normal quartz-porphyry, except that the secondary quartz in the ground-mass is coarse enough to be seen with a low-power objective. The chalcedonic portions are nearly opaque. In Portion 24, Town of Yass, the porphyry (S.387) has become chertified. In thin section, it is a mosaic of secondary quartz, with a few primary quartz grains, and iron-oxide skeletons of what have been biotite crystals. Solution channels, now filled with secondary quartz, traverse ground-mass and mineral grains alike. A rock in Portion 32, Parish of Hume, like quartzite in a hand-specimen, is identical with chertified porphyry (S.63) in thin section. The same applies to the chalcedonic type found 10 yards due west of Racecourse Trigonometrical Station (S.477).

Correlation of types described.—It is noticeable that the types, quartz-porphyry, quartz-porphyry-tuff and rhyolite-tuff have all the same mineral composition. All contain much quartz, the felspar where fresh enough for identification is in each case about $Ab_{60}An_{40}$, while the ferro-magnesian constituent is always chloritized biotite. Apatite is well represented in all. They differ, however, in texture. It seems probable that all originated from the same magma, and that their differences are due to different methods of extrusion or intrusion.

Coarse crystal tuff.—Fresh hand-specimens of this rock in some cases, for instance north-east of Laidlaw Trigonometrical Station (S.393), are difficult to distinguish from a porphyry, though in some cases the crystal tuffs are more like grits. They are grey-green in colour, weathering to a honey-yellow, and contain conspicuous grains of glassy quartz, opaque white felspar and a dark ferro-magnesian mineral. In thin section, the close packing of the quadrangular and triangular quartz and clouded felspar grains at once distinguishes these rocks from porphyry. Smaller fragments of the same minerals and of chlorite fill interstices. Calcite grains are common in some, though not found in all the tuffs. Apatite and chalcopyrite are also present in small amount. The scanty and nearly opaque matrix is secondary quartz. These rocks correspond closely to the definition of crystal tuff proposed by Pirsson (1915) and those described by Wells (1925) from North Wales. Rocks S.73, nine miles from Yass on the Wee Jasper Road, Portion 1, Parish of Boambolo; S.77, seven miles from Yass on the Goodhope Road, Portion 177, Parish of Warroo (Pl. vi, fig. 4); and S.239, Portion 18, Parish of Hume, are all typical crystal tuffs (Text-fig. 6).

Crystal-lithic tuff.—This rock is a special case of the coarse crystal tuff, since it contains rounded fragments of coarse and fine tuffs, as well as quartz and felspar crystals, in a matrix identical with that of the coarse crystal tuffs. The rock so formed is very resistant, forming tors in Portion 108, Parish of Boambolo (S.155). In thin section, though not in the hand-specimen, a resemblance to the agglomerates may be noted.

Volcanic grits.—The quartz-grits which form a conspicuous ridge to the north-west and south-east of Portion 45, Town of Yass (S.483), are composed of rounded quartz grains and an occasional iron-oxide cube, the whole being poorly cemented by an earthy paste. In thin section, the quartz grains are found to be sub-quadrangular, often due to attrition against one another, being sometimes in contact without the interposition of cement. The quartz grains, like those in the crystal-tuff outcropping nearby on the Wee Jasper Road (S.26), show numerous gaseous inclusions. The scanty matrix is of secondary quartz, felspar and calcite. These grits are crystal tuffs, in which quartz is present in greater proportion than is usual with the Yass crystal tuffs. It has also suffered greater wear. They recall the volcanic grits of the Lower Palaeozoic series of North Wales (Cox and Wells, 1920).

Quartzites.—Closely related to these grits are the quartzites or silicified grits found in Portion 8, Parish of Hume, immediately west of the middle of the rifle range (S.488), and in Portion 103, Parish of Warroo (S.157) and elsewhere. The slightly greater development of secondary quartz as a cement marks the only difference between the volcanic grits and these quartzites, whose origin is no doubt similar. The action of siliceous solutions is probably responsible for the difference between the quartzites and the grits. The cracks, strains and inclusions in the quartz of the quartzite (S.157) from Portion 103, Parish of Warroo, are also too much like those in the quartz of the Euralie agglomerate (S.126) from Portion 64, Parish of Warroo, to admit of doubt as to their similar provenance.

Agglomerates.—These fragmental rocks are almost identical throughout the area. They contain quadrangular green to brown pieces of tuff, one-quarter to one-half an inch across, set in a matrix, which also contains glassy quartz and earthy felspar grains. The pieces of tuff are almost in contact. A weathered surface is rough and pitted. In some cases the matrix is more highly silicified than in others (S.229 from the junction of Gums and Wee Jasper Roads, Portion 14, Parish of Hume). The agglomerates might be described as coarse lithic tuffs. Their character is uniform, although outcrops are widespread, and they have not been observed to be transgressive relatively to the interbedded tuffs, indeed they are everywhere conformable to them. In thin section, the lithic fragments are seen to be of fine tuff (type 3) and medium tuff (type 1), comparable with tuffs outcropping elsewhere in the area. S.182, for instance, from Portion 8, Parish of Hume, near Hatton's Corner (Pl. vi, fig. 6) contains fragments comparable with the medium tuff, S.204, an outcrop of which occurs in Portion 8, Parish of Hume, near the junction with Portion 111, Parish of Yass, as well as fragments comparable with the fine tuff, S.5, from the municipal quarry. As well as tuff, large angular quartz grains and altered felspar fragments are found in the devitrified matrix.

Medium Crystal Tuffs (Type 1).—This term has been used to describe a series of tuffs in the area, whose grain-size is about equal to that of table sugar, though they frequently contain scattered larger quartz grains. Their colour varies from grey to pink.

In thin section, the often nearly opaque ground-mass is found to be completely devitrified. It contains angular grains of primary and secondary quartz, and occasionally of weathered felspar and calcite. The last is regarded as detrital, though in some cases it may be an alteration product from felspar. Nodular lumps of interlocking crystals of secondary quartz and felspar are present in some of these tuffs, and may even be detected as white spots in the hand-specimen. They represent centres where devitrification has been greater than in the remainder of the rock. An example of a medium tuff (Type 1) is from Portion 8, Parish of Hume, immediately south of Portion 111, Parish of Yass (S.204; Pl. vi, fig. 7).

Banded or Bedded Tuff (Type 2).—These vary in colour from greenish-yellow to blue-black, while in grain-size, varieties of bedded tuffs are found to correspond to both medium and fine types (Types 1 and 3) among the non-bedded tuffs. A bedded structure is not always visible in the hand-specimen, but in thin section the long axes of rectangular or triangular grains of quartz, prisms of felspar and thin mica flakes are seen to be in a parallel arrangement within a devitrified matrix. There are tuffs with coarse mineral grains in bands about half an inch in width in the bed of the Yass River beneath the Bowspring limestone, in Portion 94, Parish of Yass (S.33), and tuffs of stages intermediate between that and the tuff at the intersection of the Goodhope and Euralie Roads, Portion 7, Parish of Warroo, where minute mineral grains are arranged in bands one-tenth of an inch wide (S.281). In the finer-grained tuffs, the bedding-planes are marked by colour banding (S.281; Pl. vi, fig. 8) or by small, discontinuous mica flakes (S.261). In the finer varieties the proportion of matrix to mineral grains is higher than in the coarser.

It is probable that this group includes tuffs whose bedding or banding is the result of two different causes. Either pressure has been the major cause, resulting in the parallel rearrangement of the mineral grains, as in S.33, from Portion 94, Parish of Yass, or slow settlement of fine particles has taken place under quiet conditions of accumulation as in Portion 7, Parish of Warroo (S.281).

Fine-grained tuff (Type 3).—In Portion 202, Parish of Warroo (S.2), this type is a dense yellowish-green rock, with earthy cream-coloured spots. In thin section, minute angular fragments of quartz and felspar are seen, set in an iron-stained ground-mass composed of nodular lumps of secondary quartz almost in contact, a few being quite large. These are the spots seen in a hand-specimen and are centres of greater devitrification than the rest of the rock. Bedding planes are roughly marked by discontinuous shreds of mica. The matrix between the devitrified lumps is nearly isotropic. A similar tuff (S.129) from the junction of the Yass River and Euralie Creek contains numerous large quartz and calcite grains (Pl. vi, fig. 9). The dense green, homogeneous, waxy-lustred rock of Portion 148, Parish of Boambolo, and adjoining portions (S.101, S.577) resembles the matrix of S.2, the minerals being distinguishable only with the high-power objective, with which may be seen secondary quartz. Tiny, brown-mica flakes, showing a rough parallelism, mark the bedding. The material contained within porphyry, beside the Yass River in Portion 97, Parish of Yass (Text-figures 1 and 2), in thin section closely resembles these types (S.624; Pl. vi, fig. 10).

Limestones.—The limestones are crystalline and coloured bluish-grey on a fresh surface. A brown weathered surface may show ribbon-shaped rock fragments, coral remnants or cavities from which fossils have been detached. A thin section shows their fragmental character, all organic remains are broken, and angular quartz-grains, sometimes large, are common. Pieces of tuff are also occasionally included. Recrystallization of calcite is observable.

Sandy shales.—The sandy shales are homogeneous, greenish-brown dense rocks with rare mica flakes. Examination with the microscope shows the quartz grains to be angular, often in contact along one side, with a micaceous, ferruginous or calcareous cement. The quartz grains are all small. In rocks standing out as ridges, such as that which contains graptolites in Portion 34, Parish of Derringullen (S.379), they are larger than in the rock of Portion 14, Parish of Hume, east of Wee Jasper Road (S.714).

Summary.

A series of conformable beds of Upper Silurian age is described, one of the uppermost containing graptolites typical of beds at the junction of the Lower Ludlow and the Wenlock divisions of the Upper Silurian of Britain and corresponds with the Yarravian of Victoria. The series includes tuffaceous and sedimentary members and, subsequent to deposition, was folded unevenly, steeper dips resulting in the western portion of the area. A geosyncline was formed about a north-west and south-east axis, with a pitch to the north-west. In places intense folding has been relieved by faulting. Porphyry was intruded between

bedding planes subsequently, though evidence of the exact time of intrusion has not been obtained. The age of the porphyry is considered to be but little later than the deposition of the sediments and it is greatly devitrified.

Text-fig. 9.—Geological Sketch-map of the Yass and Bowning districts, showing position of the graptolite-bearing beds.

Invasion of siliceous solutions along bedding-planes followed the porphyry, causing a greater intensity of devitrification in their neighbourhood, and the development of quartz crystals. Mineral vapours followed, resulting in the deposition of galena, etc.

Outcrops of rhyolite-tuff may represent a Devonian deposit connected with outcrops south of this area, or may be interbedded with the Upper Silurian series.

Lastly, alluvium was deposited by several streams, while high-level gravels mark alterations in the course of the Yass River.

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EXPLANATION OF PLATES VI-VII.

Plate vi.

1.—Quartz-porphyry, Laidlaw Trigonometrical Station, Yass (S.389), showing corroded quartz, altered plagioclase and mica set in a devitrified ground-mass. Crossed nicols. × 6½.

2.—Quartz-porphyry-tuff, Junction, Hume Highway and Canberra-Yass Road (S.169), showing large corroded and cracked quartz crystals, felspar prisms and chips of quartz and felspar between them. Crossed nicols. × 6½.

3.—Rhyolite-tuff, Portion 71, Parish of Boambolo (S.572), showing jagged outline of quartz grains, quartz and felspar chips, and flow structure in ground-mass. Ordinary light. × 6½.

4.—Coarse crystal tuff, Portion 177, Parish of Warroo (S.77), showing quartz, felspar and chlorite grains nearly in contact. Ordinary light. × 6½.

5.—Crystal-lithic tuff, Portion 90, Parish of Boambolo (S.155), showing fragments of coarse and fine crystal tuffs, quartz and felspar grains. Ordinary light. × 6½.

6.—Agglomerate, near Hatton's Corner, Portion 8, Parish of Hume (S.182), showing fragments of different varieties of tuff, quartz grains, etc., in a highly silicified matrix. Ordinary light. × 6½.

7.—Medium-grained crystal tuff (Type 1), Portion 8, Parish of Hume (S.204), showing quartz fragments, some fractured, patches of secondary quartz resulting from devitrification. Ordinary light. × 6½.

8.—Banded tuff (Type 2), Portion 7, Parish of Warroo (S.281). Ordinary light. × 2.

9.—Fine-grained tuff (Type 3), Euralie, Portion 64, Parish of Warroo (S.129), showing xenocrysts of quartz, altered felspar and calcite, strings of brown mica-flakes. Ordinary light. × 6½.

10.—Fine-grained tuff (?) within porphyry, Portion 97, Parish of Yass (S.624), showing small mica flakes intermittently marking bedding-planes, with strings of larger flakes crossing at right angles. Ordinary light. × 6½.

11.—Folded and faulted sediments in the bank of Yass River, near the mouth of Reedy Creek.

Plate vii.

Geological Sketch-map and Section of the Yass district.